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Rain attenuation at 13 GHz over a LOS terrestrial link situated in Indian eastern sector

S K Sarkar[1]*, Rajesh Kumar[1,3] and J Das[2]

[1] Radio and Atmospheric Sciences Division, National Physical Laboratory, Dr. K S Krishnan Road, New Delhi-110 012, India

[2] Electronics and Sciences Communication Unit, Indian Statistical Institute, 203, B T. Raod, Kolkata-700 035, India

E-mail sksarkar@csnpl ren nic in

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Abstract There is a dearth of experimental results on attenuation of radio wave due to rain in microwave and millimeter wave bands over this tropical part of the world. In this paper results of attenuation measurements at 13 GHz under different rainy conditions over a tropical Indian region have been presented The results on attenuation have been studied based on the simultaneous observations of rain rates A microwave communication link operating at 13 GHz belonging to an operational agency was monitored and rain rate measurements were carried out on twenty-four hours basis during July-August 2001 by a rapid response rain gauge having integration time ~ 10 sec. The results on attenuation are useful to design future communication links in tropical region

Keywords Microwave communication link, signal level, rain attenuation, rain rate, 13 GHz and correlation

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1. Introduction

The growing demand of more channels in radio communication systems and congestions in UHF (Ultra High Frequency) and lower region of microwave bands have necessitated to use frequencies higher than 10 GHz in India [1, 2]. There are several effects of rain on radio wave such as absorption, scattering, depolarisation etc., in microwave and millimeterwave frequency band [3, 4]. Among the several effects, attenuation of radiowave due to rain because of high dielectric constant of water is the most important one [5-7]. There is paucity of the measured results on attenuation of radiowave due to rain over the tropical regions in India.

The LOS (Line-of-Sight) communication link operating at 13 GHz situated between Belur Moth and Tirriti Bazar having path length ~ 6.5 km and located over Calcutta (22.32°N, 88.27° E) region was monitored on twenty-four hours basis during July–August 2001. A rapid response rain gauge was also put on operation to measure the rain intensity. It has been seen that the signal level is characterized with steady signal of the order – –44 dBm with a fade of 1 dB under clear air (without precipitation) situation. The communication link used to exhibit heavy loss of signal even during moderate rain. Under heavy rain attenuation as high as ~ 29 dB was observed. The analysis of the results on signal levels and rain rates has yielded the percentage of time and its association with the particular level of attenuation during monsoon months, July and August over Calcutta region. These results are useful to determine quality of service of links over this region.

2. Source of data

A strip chart recorder recorded the amplitude variations of the microwave communication link of Calcutta Telephone (BSNL) between Belur Moth and Tirriti Bazar. The carrier intensity measurements were made on twenty-four hours basis during July–August 2001. The transmitter is situated at Belur Moth

*Corresponding Author
[3] Present address : 214, School of Environmental Science, Jawaharlal Nehru University, New Delhi-110 067, India

while the receiver is situated at a distance of ~ 6.5 km at Tirriti Bazar. The transmitter power is ~ 22 dBm. The free space transmission loss is ~ 131 dB. The rain rate measurements were carried out over Calcutta during July–August, 2001 by a rapid response rain gauge having integration time ~ 10 seconds. The rain gauge was located at the transmitter site. July and August are the months when maximum rainfall takes place over Calcutta region. It is seen that in July and August, the total rainfall are ~ 300 mm and 306 mm respectively. The rapid response rain gauge used for the present study is a microprocessor based system. It monitors rain intensity automatically. The program controls the sampling, storing and printing of the data of rain intensity. The rain water is collected in a collector and converted into approximately equal size drops and the number of drops for 10 sec time period are counted electronically. The counts are then coverted into corresponding rainfall rates expressed in mm/hr.

3. Results and discussion

The representative diagrams of two rain events, measured over Calcutta by the rapid response rain gauge having integration time ~ 10 sec are presented in Figures 1 and 2. The rain rate is

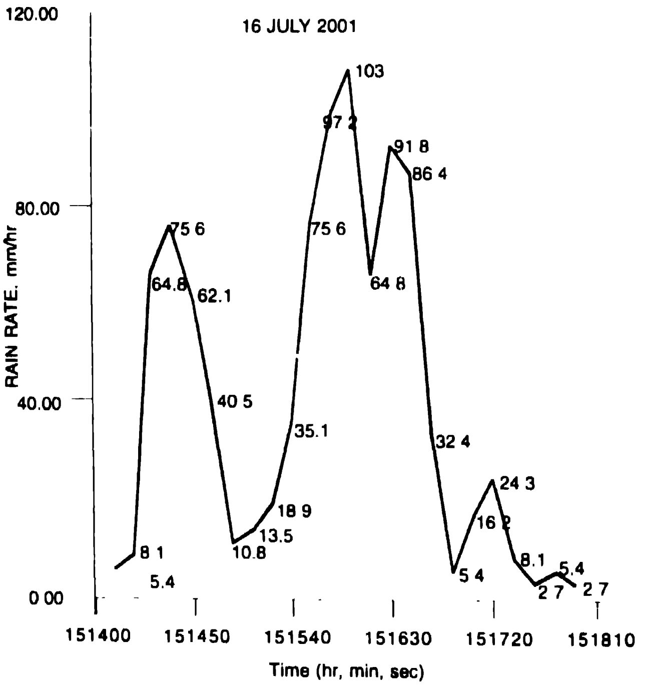

Figure 1. Typical rain event measured on 16 July, 2001 by rapid response rain gauge over Kolkata

characterized with slow and rapid variations. The variation of rain rates is similar to the amplitude variation of microwave radio signals and can give insight into the fade dynamics due to rain, for determining the fading margin and hence the performance of the link. It is seen in Figure 1 that the variation of rain intensity is fast and the maximum rain rate ~ 103 mm/hr has been observed. The variation of rain intensity observed in another rain event is presented in Figure 2. It is seen in Figure 2, that the variation of rain intensity with time is slow as compared to the rain event shown in Figure 1. However, the maximum rain intensity in this rain event is around ~ 170 mm/hr. The cumulative distribution of rain rate has been presented in Figure 3. It is seen that the rain rate ~ 15 mm/hr exceeds for 50% of the time and rain rate ~ 32 mm/hr exceeds for 20% of time.

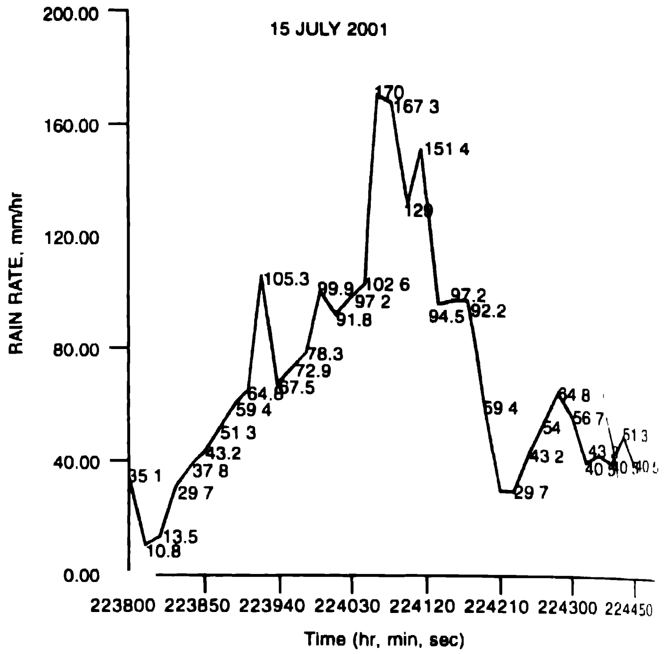

Figure 2. Typical rain event measured on 15 July, 2001 by rapid response rain gauge over Kolkata

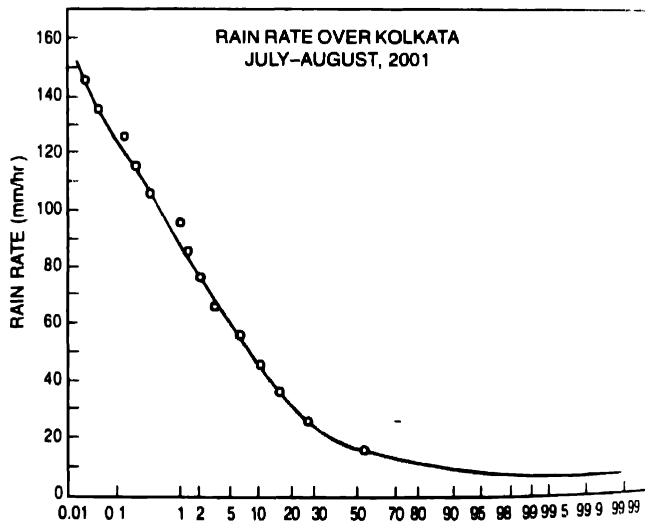

Figure 3. Probability distribution of rain rate during July-August, 2001 over Kolkata.

The amplitude variation observed under different rainy condition is presented in Figures 4 to 7. The microwave amplitude variation under normal condition *i.e.* during clear air situation when there is no precipitation is very steady. The microwave amplitude variations observed during drizzle (around 5 mm/hr to 10 mm/hr) are shown in Figure 4. It is seen in Figure 4 that the maximum attenuation is around ~ 2 dB and the pattern of variation of the signal level is quite similar in all the cases. The minimum signal level under the moderate rain (around 15 mm/hr to 80 mm/ is found to be ~ – 50 dBm (Figure 5]. Some more diagrams on amplitude variations when maximum attenuation is around 12 dB is presented in Figure 6a and 6b. Simultaneously obtained rain rate and attenuation records for two rain events are also presented in Figure 6. The amplitude variation measured during heavy rain are shown in Figures 7. It is seen in Figure 7 that the

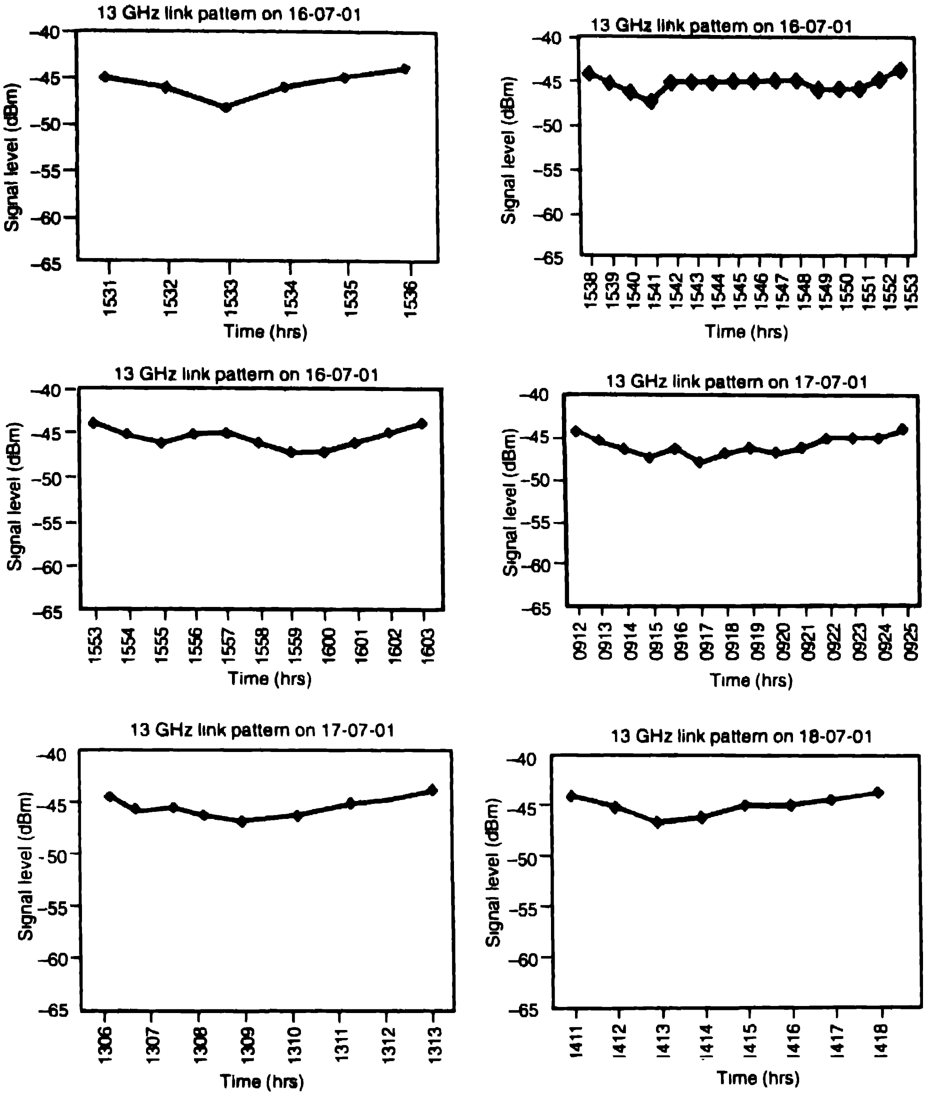

Figure 4. Typical cases of microwave amplitude variation observed during drizzle.

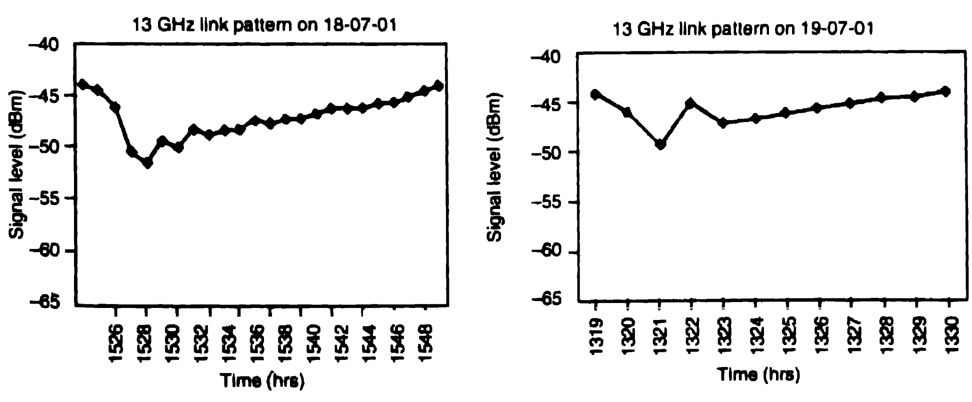

Figure 5. Microwave amplitude variations under moderate rain

maximum attenuation observed during heavy rain (≥ 90 mm/hr) has been found to be as high as ~ 29 dB. The minimum signal level has been found to be ~ – 73 dBm. However, the link performance was satisfactory even when the signal level touched such low value.

The probability distribution of observed attenuation is presented in Figure 8. It is seen that under normal condition when there is no precipitation, the measured signal level is ~–44 dBm. The results on attenuation have been derived by taking the difference of the normal signal level ~ –44 dBm and the instantaneous signal level in dBm. If the observed signal level

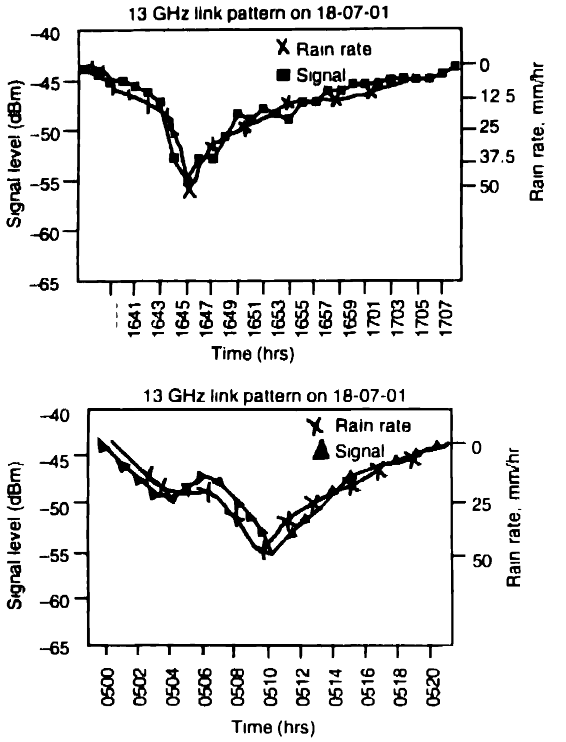

Figure 6. Amplitude variations when attenuation as high as 12 dB were observed

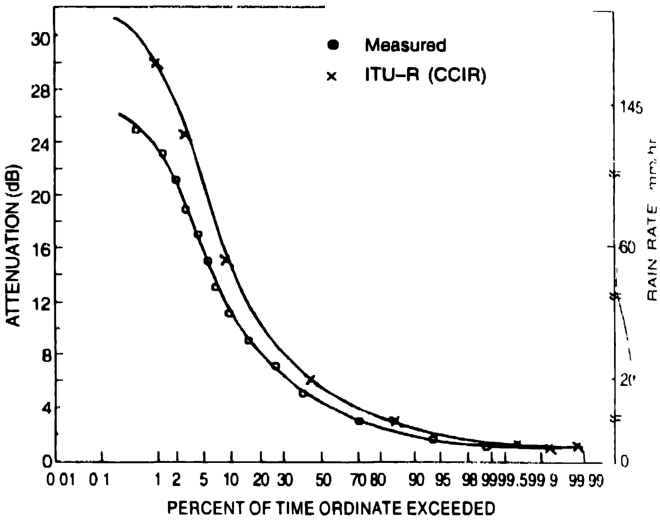

Figure 8. Comparison of measured attenuation and attenuation result deduced from ITU-R model

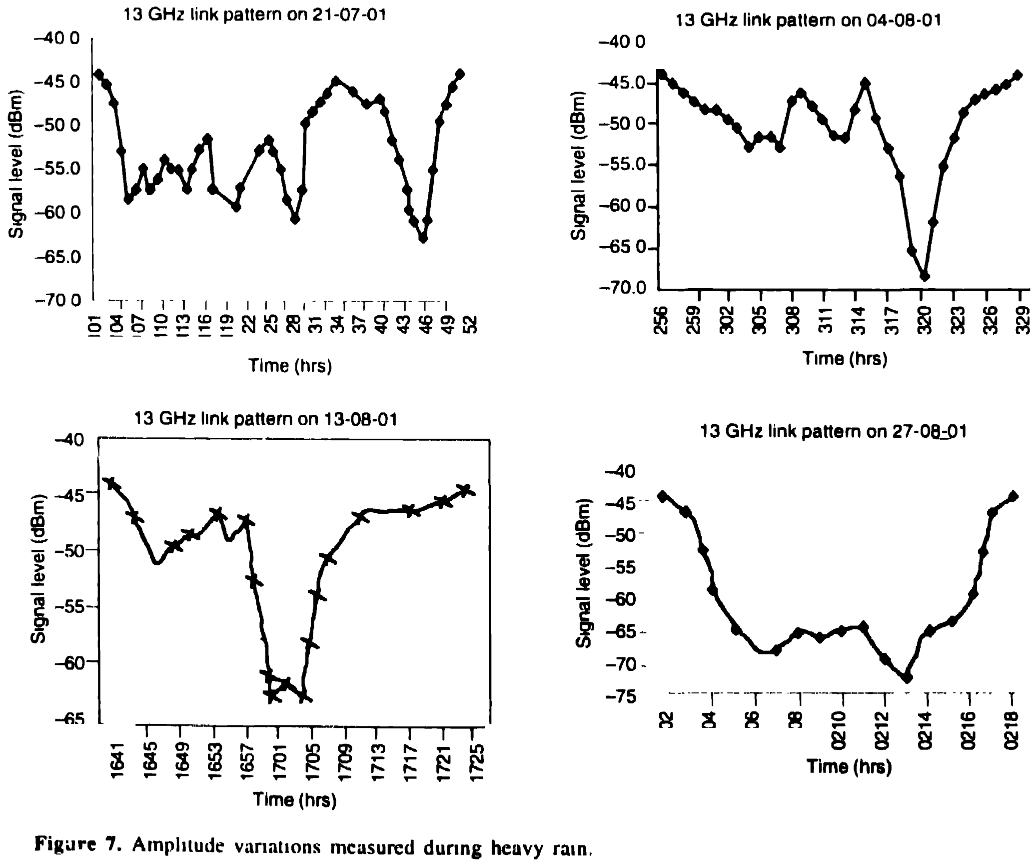

Figure 7. Amplitude variations measured during heavy rain.

ia time is – –54 dBm, then the estimated attenuation is 10 dB. he results on attenuation of the radio wave of ~ 13 GHz easured under different rain intensities are also presented in igure 8. It is seen in Figure 8 that the attenuation increases ith rain rates. The observed attenuation is around ~ 6 dB at 20 m/hr and it is 16 dB at 60 mm/hr. The attenuation ranging etween ~ 15 dB and 27 dB is found to be associated with rain ate from ~ 55 mm/hr to 145 mm/hr. The link serves the purpose ven though its signal suffers large attenuation under heavy ttenuation. The results on attenuation at different rain rates, educed from the ITU-R model [8] (earlier known as CCIR [9]), ι – 02515R$^{1.164}$ have also been included in Figure 8. The ttenuation values deduced from ITU-R model particularly at igher level, intermediate level as shown in Figure 8 show quite easonable good agreement with the measured results. But at ery high rain intensities the ITU-R model overestimates the ttenuation results.

I. Conclusion

The simultaneous observations of carrier intensity at 13 GHz nd rain rate measurements suggest that the signal level suffers eavy attenuation for considerable percentage of time during July-August, 2001. The measured results have also compared with the results deduced from the ITU-R model. The comparison etween the reuslts indicates that at very high rain rates the ITU-R model overestimates the attenuation values. Such ttenuation measurements at different frequencies over different propagation paths under varied path length should be taken to develop a suitable rain attenuation prediction model for this part of the world.

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